

JAPANESE POLAR EXPERIMENT (POLEX) IN THE ANTARCTIC IN 1978–1982

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Abstract: In conjunction with the polar sub-programme within the objectives and planning framework of the Global Atmospheric Research Programme (GARP), the Japanese Polar Experiment (POLEX) is designed to augment and contribute to the First GARP Global Experiment (FGGE) in 1978–1979. This paper outlines planning and implementation of the Japanese POLEX-South which is carried out in the Antarctic by the Japanese Antarctic Research Expedition from 1978 to 1982. At Syowa Station in the Lützow-Holm Bay area of East Antarctica, routine weather observations, data acquisition from meteorological satellites, studies on the heat budget of sea ice, and radiation characteristics of atmosphere and cryosphere are carried out. Mizuho Station in the inland is occupied during the POLEX-South; the main subject of research for 1979 is the radiation budget and the air-ice sheet interactions; observations of surface inversion layer is the main subject for 1980; and regional weather and climate regime in a wide area is the main research subject in 1981. Current status of data processing and numerical experiments are described briefly.

1. Introduction

From the early 1970's, international communities of polar meteorologists, glaciologists and oceanographers have been convened several times to formulate an international plan to study the key interactions between the ocean, ice and atmosphere in the Southern Ocean around Antarctica and over the Antarctic Continent. Their efforts came out as a part of the polar sub-programme for the Global Atmospheric Research Programme (GARP) which is a joint research programme of the International Council of the Scientific Unions (ICSU) and the World Meteorological Organization (WMO). The objectives of the polar sub-programme are as follows (INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS AND WORLD METEOROLOGICAL ORGANIZATION, 1978):

- (1) To identify and study those processes of particular importance in the polar regions relating to the improvement of weather prediction from general circulation models (first GARP objective), and
- (2) To develop a basis for understanding the role of ice in climate dynamics through: (a) parameterization of sea ice dynamics and related atmospheric and

oceanic processes in climate models, and (b) establishment of an appropriate information base for studies of the role of sea ice and polar continental ice masses in climate change (second GARP objective).

The polar sub-programme consists of two components: first a Polar Experiment (POLEX) (in both north and south polar regions) which is designed to contribute to the First GARP Global Experiment (FGGE), and second, continuing studies both before and after the FGGE related to the climatic objective of GARP. The following specific tasks for POLEX have been established:

- Task 1. Improvement of the global data base in polar regions.
- Task 2. To provide calibration and ground truth for satellites.
- Task 3. Modelling efforts to improve understanding of high-latitude processes for FGGE.
- Task 4. To specify and collect data for the FGGE climate research set.

Participation of Japanese polar research communities in the polar sub-programme was undertaken by the Japanese National Committee for GARP, Science Council of Japan, and an *ad hoc* committee for POLEX was organized. In parallel with the activities of the National Committee for GARP, advisory bodies to the director of the National Institute of Polar Research, which is the Japanese Antarctic operation agency, have been working on the planning and implementation of the POLEX-South. In the plan of the Japanese polar sub-programme, the research in the Antarctic was emphasized because of the continuing activities of the Japanese Antarctic Research Expedition (JARE), occupying Syowa Station (69°00'S, 39°35'E) on East Ongul Island in Lützow-Holm Bay and Mizuho Station (70°42'S, 44°20'E; altitude 2230 m) in Mizuho Plateau.

The planned Japanese polar sub-programme consists of three parts: POLEX-North observations at Inuvik, Canada in the winter of 1979–1980; POLEX-South observations in the Antarctic from 1978 to 1982; and numerical experiments at home laboratories. The official approval of the Japanese polar sub-programme was obtained in 1977. The international “POLEX” refers to the experiments directly contributing to and to be carried out simultaneously with the FGGE which is to be operational in 1978 (build-up year) and 1979 (FGGE operational year; there are two Special Observing Periods). However, the Japanese POLEX-South includes research programmes which are to be carried out after the FGGE. This is due to the situation that JARE had been committed to the upper atmosphere physics research for the International Magnetospheric Studies (IMS) between 1976 and 1978. Thus the commencement of field observations of the POLEX-South was postponed one year but it was scheduled to continue for three years from January 1979 to January 1982 by the 20th JARE (JARE-20), JARE-21 and JARE-22. However, the routine weather observations at Syowa Station and Mizuho Station were conducted in 1978.

The POLEX-North observations in northern Canada in 1979–1980 winter were successfully carried out following the plan as laid out. Numerical experiments for the POLEX-South include modelling of radiation budget, formation of Antarctic Bottom Water and currents, and structure of katabatic winds. These experiments along with those for the Arctic are in progress.

2. Plan of Japanese POLEX-South

Continuation of surface synoptic observations at Syowa Station and Mizuho Station and twice daily upper-air observations at Syowa Station is an undoubtedly pertinent contribution to the GARP objectives and POLEX tasks. Taking this situation into consideration, the Japanese POLEX-South programme was planned to comprise three major research subjects: 1) radiation budget, 2) air-cryosphere-ocean interactions, and 3) circulations of polar atmosphere.

- 1) Radiation budget
 - a) radiation characteristics of cryosphere surface
 - b) radiation characteristics of clouds
 - c) radiation characteristics of haze, ice crystals and blowing snow
 - d) vertical distribution of radiation budget
- 2) Air-cryosphere-ocean interactions
 - a) structure of surface boundary layer and heat budget of air-cryosphere interface
 - b) structure of the Ekman layer and the internal gravity waves
 - c) regional characteristics of falling snow and deposited snow
 - d) air-ocean interactions
- 3) Circulations of polar atmosphere
 - a) structure of surface inversion layer
 - b) local weather and climatic characteristics
 - c) distribution and characteristics of clouds
 - d) mechanism of solid precipitation
 - e) structure of cyclones and their role in the heat transport
 - f) structure of katabatic wind

Observational plan to implement the above-mentioned research subjects is described below:

1) Radiation budget: Both at Syowa Station and Mizuho Station, various types of radiometers will be installed on the surface and on an observation tower. Airborne measurements of radiation budget profiles and the surface radiation temperature will be carried out from small aircraft stationed at Syowa Station. Measurements of radiation budget by means of radiometer sondes are planned at Syowa Station.

2) Air-cryosphere-ocean interactions: About 30 m high observation tower

will be erected at Mizuho Station and detailed observations of surface boundary layer will be carried out to clarify the energy and mass transport near the surface. Observations of blowing snow, heat flow in the surface snow layer, and relevant glaciological observations will be carried out. In the vicinity of Syowa Station, heat budget studies of sea ice will be carried out.

3) Circulations of polar atmosphere: In addition to the upper-air observations at Syowa Station, low-altitude radiosondes will be released at Mizuho Station. Observations of lower layers with sonic-wave sounders at Syowa Station and Mizuho Station are planned. Installation of unmanned weather stations in the inland is planned, distributed mainly along the flow line of katabatic wind. Surface synoptic and upper-air observations in the inland area will be carried out by oversnow traverse parties.

In addition to these observational plans, data collection facilities for meteorological satellites (TIROS and NOAA series) at Syowa Station will be amplified.

Observations in 1979 will be started by the members of JARE-20 (1978–1980) and will be terminated in January 1982 by JARE-22 (1980–1982). Major tasks of each year are: radiation budget and surface boundary layer observations in 1979; structure of surface boundary layer and heat budget of sea ice in 1980; glacial-meteorological observations at Mizuho Station and local weather observations in the inland in 1981. Allocated observers each year are 4 personnel for routine weather observations at Syowa Station and 3 scientists at Mizuho Station and/or Syowa Station. Participating agencies of the POLEX-South are: Japan Meteorological Agency, Hokkaido University, Tohoku University, Nagoya University (Water Research Institute), Kyoto University (Disaster Prevention Research Institute), and National Institute of Polar Research (the present author is the representative of the POLEX-South programme).

3. Current Activities

Research programme in 1979 was carried out by the JARE-20 (1978–1980) at Syowa Station and Mizuho Station. Airborne observations were carried out in the vicinity of Syowa Station in January 1980. Four personnel from the Japan Meteorological Agency were responsible for routine weather observations at Syowa Station (International index 89532). Three scientists (Shinji MAE, Makoto WADA and Takashi YAMANOUCHI) stayed at Mizuho Station (89544) in rotation to carry out surface synoptic and special observations for POLEX-South.

A 30 m high observation tower was erected at Mizuho Station in January 1979 and various kinds of meteorological instruments were installed on the tower. These instruments were: 4 pyranometers for global shortwaves (305–2800 and 695–2800 nm in wavelength) and reflected shortwaves (305–2800 and 695–2800 nm) at the top of the tower, 2 pyrgeometers at the top of the tower, anemometers and thermometers

(at 30, 16, 8, 4, 2, 1 and 0.5 m), and 2 wind vanes (30 and 2 m). Instruments installed at the snow surface were: 8 pyranometers (global and reflected, wavelength 305–2800, 530–2800, 630–2800 and 695–2800 nm), 2 pyrgeometers (incoming and outgoing), 1 pyrliometer (direct solar radiation, 6 windows, 3 wavelength regions), 1 net pyrradiometer, 1 thermometer at the air-snow boundary, 1 radiation thermometer (1 m height), 1 hygrometer (1.5 m), 1 drifting-snow meter (height varies). Instruments installed below the snow surface were: 6 thermometers (0.1, 0.5, 1, 3, 5 and 10 m), 3 thermal-flux meters (0.1, 0.5 and 1 m). Recording systems of radiation and micrometeorological elements were installed in a laboratory, where a barometer was set, about 3 metres below the surface. All the measured values including atmospheric pressure were sampled every minute and recorded with magnetic tape recorders and monitored with analog recorders. MAE *et al.* (1981) reported the installation of these observation systems and performance.

Data of surface synoptic observations at Mizuho Station in 1979 were published by WADA *et al.* (1980). Results of preliminary data processing of radiation observations were published by YAMANOUCHI *et al.* (1981) and micrometeorological data were published by WADA *et al.* (1981) in JARE Data Reports.

An unmanned weather station to measure the air temperature, winds, and solar radiation was established in the inland (Station Y100 at 71°17'S, 46°19'E, elevation about 2600 m) on 17 October 1979, but the performance was unsuccessful because of the malfunction of wind generators. The station was reactivated in January 1980. During the oversnow traverses between Syowa and Mizuho Stations and between Mizuho Station and Y100, surface accumulation was measured with offset markers and the ice thickness between Syowa and Mizuho Stations was measured with radio-echo sounders both on board the aircraft and surface vehicle. The data of these glaciological observations taken between February 1979 and January 1980 were published by WADA *et al.* (1981).

It is to be added that 7 FGGE drifting buoys supplied by Australia were deployed from the relief ship FUJI during her cruise from Fremantle, Western Australia to the Antarctic between 17th and 23rd of December 1979. Routine weather observations at Syowa Station were carried out and 11 radiometer sondes were released in 1979.

On 13th and 14th January 1981, the Third Symposium on Polar Meteorology and Glaciology was held at the National Institute of Polar Research, where the results of research on the Japanese POLEX, including both North and South and numerical experiments, were presented and the proceedings are published (KUSUNOKI, 1981).

For the POLEX-South observations in 1980 the JARE-21 led by Sadao KAWAGUCHI (meteorologist) took the responsibility; three scientific personnel S. KOBAYASHI, N. ISHIKAWA and T. OHATA were in charge of research at Mizuho Station and Syowa Station, and 4 weather observers engaged in the routine observations at Syowa

Station. Items of observations at Syowa Station were: surface synoptic and upper-air observations, radiometer sondes release (20 times) and sonic-wave sounder operation (February 1980 to January 1981).

Sea ice research at Syowa Station was delayed by the heavy blizzard hit on 17–18 March 1980 which resulted in the loss of sea ice around the station and the loss of one Cessna-185 aircraft which had been tethered to the sea ice. However, the sea ice research programme was carried out from June to December 1980, measuring the air and water temperatures, dew point, ice thickness, incident radiation, reflected radiation, net radiation, wind speed and direction, heat-flux and radiation in snow cover. Airborne survey of radiation budget, surface radiation temperature and surface morphology was carried out in October 1980. Ice thickness data around the station were collected.

At Mizuho Station, surface synoptic observations were continued in 1980; observations with the 30 m tower were also continued but with somewhat reduced numbers of instruments. Observations of sonic-wave sounder were continued. Observations of surface inversion layer were emphasized releasing more than 70 low-altitude radiosondes in 1980. Two trips to maintain the unmanned weather station at Y100 were made in August and October 1980.

In January 1981, three POLEX-South personnel (J. INOUE, K. SATO and H. NISHIMURA) of the JARE-22 took over the observations at Mizuho Station. Surface synoptic observations are continued. Starting from Mizuho Station, oversnow traverse parties are making observations of surface and upper-air weather and related glaciological phenomena. Installation of unmanned weather stations in the inland is planned and an oversnow traverse from Mizuho Station to the Yamato Mountains will be carried out in the 1981–1982 austral summer to reveal local weather and climatic conditions of the Yamato Mountains area. Observations at Syowa Station will be continued on a routine basis.

References

- INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS AND WORLD METEOROLOGICAL ORGANIZATION (1978): The Polar Sub-Programme. Geneva, 47 p. (GARP Publications Series, 19).
- KUSUNOKI, K. ed. (1981): Proceedings of the Third Symposium on Polar Meteorology and Glaciology. Mem. Natl Inst. Polar Res., Spec. Issue, 19, 320 p.
- MAE, S., WADA, M. and YAMANOUCHI, T. (1981): The system of measurements of radiation and micrometeorological elements at Mizuho Station, East Antarctica: Installation and performance. Nankyoku Shiryo (Antarct. Rec.), 71, 44–57.
- WADA, M., YAMANOUCHI, T., MAE, S. and KAWAGUCHI, S. (1980): Meteorological data at Mizuho Station, Antarctica in 1979. JARE Data Rep., 57 (Meteorology 7), 91 p.
- WADA, M., YAMANOUCHI, T. and MAE, S. (1981): Glaciological data collected by the Japanese Antarctic Research Expedition from February 1979 to January 1980. JARE Data Rep., 63 (Glaciology 7), 43 p.
- WADA, M., YAMANOUCHI, T., MAE, S., KAWAGUCHI, S. and KUSUNOKI, K. (1981): POLEX-South

data, Part 2: Meteorological data at Mizuho Station, Antarctica in 1979. JARE Data Rep., **62** (Meteorology 9), 321 p.

YAMANOUCHI, T., WADA, M., MAE, S. and KAWAGUCHI, S. (1981): POLEX-South data, Part 1: Radiation data at Mizuho Station, Antarctica in 1979. JARE Data Rep., **61** (Meteorology 8), 350 p.

(Received April 22, 1981)